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On Farm Phenotypic Characterization of Indigenous Sheep Type in Bensa District, Southern Ethiopia

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Abstract
The study was carried out in Bensa district of Sidama Zone, southern Ethiopia; with an objective to characterize indigenous sheep type with respect to morphology characteristics and physical linear traits. A total of 574 sheep were sampled randomly, and stratified into sex and dentition groups (0PPI, 1PPI, 2PPI, 3PPI). Both qualitative and quantitative data were analyzed using SAS versions 9.1.3 (2008). The main frequently observed coat color pattern of sampled male and female sheep populations was patchy (51.9%) while the most observed coat color type was red followed by mixture of red and brown. Sex of the sheep had significant ($p>0.05$) effect on the body weight and linear body measurements except ear length, pelvic width, tail length and rump length. Dentition classes of sheep contributed significant differences to body weight and the linear body measurements except ear length. The correlation coefficient between body weight and other linear body measurements were positive and significant ($p<0.05$) both for male and female sheep. The result of the multiple regression analysis showed that chest girth alone could accurately predict body weight both in female and male of sampled population of indigenous sheep with the equation $y = -20 + 0.67x$ for females and $y = -29 + 0.8x$ for males, where y and x are body weight and chest girth, respectively. It was concluded that for breed improvement program and to boost productivity of indigenous sheep population, phenotypic characterization is the baseline so; this preliminary work could be used to support genetic characterization to determine the population.
Keywords: Indigenous sheep, Linear body measurements

1. INTRODUCTION

Ethiopia is home for most populous and diversified indigenous sheep breeds/populations in Africa. There are about 14 traditionally recognized sheep populations in Ethiopia, which are classified into nine genetically distinct breeds and 6 breed groups (Solomon, 2008). The country has about 26 million heads of sheep, of which about 75% is found in the highlands where mixed crop-livestock production systems dominate, while the remaining 25% is found in the lowlands (DAGRIS, 2006; CSA, 2013). In Ethiopia sheep are widely distributed across the diverse agro-climate prevalent in the country. Sheep production in Ethiopia is based on indigenous breeds which account for about 99.78% of the total national sheep population (CSA, 2014).

Characterization of animal genetic resources encompasses all activities associated with the identification, quantitative, and qualitative description, and documentation of breed populations and the natural habitats and production systems to which they are adapted on. The aim is to obtain better knowledge of Animal Genetic Resources (AnGR), to their present and potential future uses for food and agriculture in defined environments, and their current state as distinct breed populations (FAO, 2007). Genetic and phenotypic characterization of locally available farm animal populations provides essential information to make rational decisions for the improvement and the development of effective breeding programmes. In developing regions, there exist types of farm animal species which owe their distinct identity to a combination of traditional 'breeding objectives' and geographical and/or cultural separation by communities which own them (Mwachero and Rege, 2002). Previous studies on Ethiopian sheep limited only on few specific sheep types in the country such as such as Horro, Menz, Afar and Bonga and/or are based on few animals (Galal,1983;Kassahun, 2000;Solomon,2002;Sisay,2002;Zewdu *et al*., 2010; Getachew *et al*.,2010;). Morphologically characterized sheep types in Gamogofa, Sidama-Gedeo, Gurage -Silte, Kembata Tembaro –Hadya and Wolaita zones and very few woredas of SNNPR were undertaken(Abera *et al*., 2013). Molecular characterization of 14 sheep types was also studied by Solomon (2008). However, information on sheep types in some pocket areas of Southern Nation Nationalities and Peoples Region is lacking.

Bensa is one of the 19 Districts of Sidama zone, Sothern Ethiopia, which was identified for LIVES (Livestock and Irrigation Value chains of Ethiopian Smallholders project of the International Livestock Research Institute) interventions based on the potential of high value livestock commodities including sheep. It is one of the leading district's in terms of sheep population from Sidama zone. However, an effort made to characterize the indigenous sheep population of the district was nil. The objective of this study was, therefore, to morphological characterizing indigenous sheep population in the study area.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study was conducted in Bensa district of Sidama Zone in Southern Nations Nationalities and Peoples' Region (SNNPR) of Ethiopia. Bensa district is one of the 19 districts in Sidama zone that extends into the Oromia region of Bale Zone of Oromia Region. It is bordered on the South and North by the Oromia Region, with Bona Zuria on the west, Arbegona district on the NorthWest, Chere district on the East, and Aroresa district on the Southeast. Daye, the capital of Bensadistrict, is located at 420 kms South east of Addis Ababa and 135kms northeast of Hawassa city, the SNNPR capital city.

Bensa district is located at altitude which ranges from 1452 to 3129 meters above sea level (m.a.s.l.). The two rainy seasons are the *belg* (short rainy season), which covers from late February to May, and the *kremt* (main rainy season), which extends from late June to early October. The annual average rainfall of the area is 1208.5mm. The average temperature of the district is 19^{o}C. The district has 3 major agro-ecologies where about 50% is moist weynadega (mid-altitude), 36% moist dega (highland) and 14% moist kola (lowland (LIVES, 2012).

2.2. Sampling Techniques

Bensa district was selected purposively based on the high value livestock and irrigation commodities including sheep by the Livestock and Irrigation Value Chain for Ethiopian Smallholders (LIVES) Project (www.lives-ethiopia.org). A selection of the studied kebele was done using multi-stage purposive sampling technique in consultation with district bureau of livestock and fishery experts. One potential kebele was selected from the district based on the population of sheep to study quantitative and qualitative traits indigenous sheep. Measurements were made on individual animals from 446 randomly selected females and 128 randomly selected males in the study area. Every Animal to be measured was identified by sex and dentition. Morphological measurements were taken from each individual animal (0PPI to 3PPI) that were available in sampled sheep population in study area. All sampled sheep were individually handled and dentition characters were used to determine the age correlated in each case by owner's information.

2.3. Data Collection

Quantitative (body measurements) and qualitative (morphological characters) data were collected based on age groups and recorded on the format adopted from the standard description list developed by FAO (2012) and ILRI (International Livestock Research Institute)-OADB (Oromiya Agricultural Development Bureau) for survey of livestock breeds in Oromiya (Workneh and Rowlands, 2004).The standard breed descriptor list for the sheep developed by FAO (2012) was closely followed in selecting morphological variables

Qualitative traits like coat color pattern, coat color type, hair type, head profile, ears, wattle, horn, ruff and tail were observed and recorded. Quantitative traits like body measurements viz., Chest Girth (CG), Body Length (BL), Wither Height (WH), Ear Length (EL),Tail Length (TL), Tail circumference (TC),Chest Depth (CD),Pelvic width (PW) and Scrotum circumference (SC) were measured using flexible measuring tape while body weight (BW) was measured using suspended spring balance having 50kg capacity with 0.2kg precision. Each morphologically measured animal was identified by sex and age group. Sheep was classified into four age groups; no pair of permanent incisor (0 PPI), 1 PPI, 2 PPI and 3 PPI to represent age of less than 15 months, 15.5 to 22.0 months, 22.5 to 27.0 months and 28.0 to 38 months, respectively based on the finding of Wilson and Durkin (1984) for African sheep breed. Body condition score (BCS) was assessed subjectively and scored using the 5 point scale (1= very thin, 2 = thin, 3= average, 4 = fat and 5 = Very fat/ obese) for both of the sexes according to Hassamo *et al. (*1986). Linear body measurements were taken by restraining and holding the animals in a stable condition.

2.4. Data Managements and Analysis

The data collected was checked for any inconsistency and corrected, and then coded and entered into computer. The collected data on morphological and qualitative data were entered into Microsoft EXCEL software's.

Qualitative data from individual observation was analyzed following the frequency procedures of SAS version 9.1.3(2008). The General Linear Model (GLM) procedure of SAS was employed to analyze quantitative variables. Sex and age group were fitted as fixed independent variables and body weight and a linear body measurement except scrotum circumference was fitted as dependent variables. Tukey's test was used to separate means when significant difference was detected.

The models for analyzing quantitative data except scrotal circumference were:

$y_{ijk} =$ $+ A_i + S_j + (AS)_{ij} + e_{ijk}$

Where: Y_{ijk} = the observed *k* (body weight or linear body measurements except scrotum circumference) in the i^{th} age group and j^{th} sex

= overall mean

A_i = the effect of i^{th} age group (0-3 pair permanent incisor)
S_j= the effect of j^{th} sex (j= male or female)
$(AS)_{ij}$= the effect of interaction of i of age group with j of sex
e_{ijk} = random residual error
Model to analyze the scrotum circumference was:
Y_{ij}= + A_i+ e_{ij}
Where: Y_{ij} = the observed j (scrotum circumference) in the i^{th} age group
= overall mean
A_i = the effect of i^{th} age group (0-3pair permanent incisor)
e_{ij} = random residual error
Multiple linear regressions were used to estimate the body weights of sheep from various body measurements. The association between body weight and linear measurements were assessed using Pearson's correlation coefficient in SAS version 9.1.3 (2008). The following models were used for estimation of body weight from linear measurements:-
For male:

$$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + e_j$$

Where:
Y_j = the response variable; body weight
α = the intercept
X_1, X_2, X_3, X_4, X_5, $X_6$and $X_7$are the explanatory variables chest girth, body length, height at withers, pelvic width tail length, tail circumference and scrotal circumference, respectively.
$\beta 1, \beta 2, ..., \beta 7$ are partial regression coefficients of the variables $X1, X2, ..., X7$
e_j= the residual random error
For female:

$$Y_j = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + e_j$$

Where:
Y_j= the dependent variable body weight
α = the intercept
X_1, X_2, X_3, X_4, $X_5$and $X_6$are the independent variables; chest girth body length, height at wither, pelvic width, tail length and tail circumference, respectively
$\beta 1, \beta 2, ..., \beta 6$ are partial regression coefficient of the variable $X1, X2, ..., X6$
e_j = the residual random error

3. RESULTS AND DISCUSSIONS

3.1. The Origin and Features of Indigenous Sheep

Most of the farmers did not have any idea about the origin of indigenous Sheep in the study area. However, some sheep producers suggested that indigenous sheep was spread from Arbegona,Bura and Hagereselam of Sidama highlands to Bensa and others surrounding districts. Focus group discussion (FGD) with elders indicated that indigenous sheep was kept for the past centuries by their ancestors and transferred to the current generation. The smallholder preferred this sheep population because it has fast growth, short lambing interval and resistance to disease, adaptability to cold climatic condition, acceptable meat quality, fat tail and coat color.

Figure 1. Indigenous male sheep (left) and female sheep (right)

3.2. Qualitative traits of the sample population

Qualitative traits of indigenous sheep population of the study area are summarized in Table 1. Out of the total sampled sheep population in the study area about 19.70% had thin (scored 2 in scale of 5) body condition while about 71.14% had average (scored 3) and 9.16% had fat (> 3 score) during the study period. The coat color pattern of indigenous sheep population in the study area was 47.43% plain, 51.90% patchy and 0.68% spotted coat color. The main dominant coat color types were red (22.46%), red and brown (19.58%), light red (13.85%) and white with red color (12.65%). Besides, white (7.98%), brown (1%), black (4.90%), grey (1.56%), dark brown (8.06%) and black and white (7.97%) coat color were observed in plain, spotted and patchy pattern. The indigenous sheep had dominant patchy color pattern. The result is consistent with Arsi Bale sheep (Solomon, 2008).The higher proportion of animals with red coat colour could be a reflection of strong selection for animals manifesting red colour to meet the preference of market demand. The majorities (81.96%) of sampled population of study area had medium and smooth hair type followed by short and smooth (14.63%) and long and smooth (3.41%). The observed hair type was similar with Dawuro and Konta sheep types reported previously (Amelmal, 2011).

The face profile of most of the sample population was flat (73.4%) followed by convex (13.57%) and concave (13.03%). Moreover, majority of the sheep population do not have wattle (94.4%), and all of them had no ruff. The majority of the sampled sheep population had straight tip (95.58%) tail sheep while the others (4.42%) had tail shape twisted end curved at tip. Almost 99.89% of the sampled population had long fat tail. Similarly, Solomon (2008) reported that Arsi-Bale sheep had long fat tailed with some of them having tail shape which is twisted at the end and all had hair fiber type.

The most dominant ear orientation or form of sampled sheep population of female was carried horizontal (73.54%) followed by semi pendulous(21.30%) and erect(5.15%) whereas the male was carried horizontal (46%) followed by semi pendulous(38.30%) and erect(15.62%) .The majority (74.89%) of the females' sheep were polled whereas 87.5% of the male sheep were horned. Out of the horned male sheep, 56.25% had spiral horn shape followed by straight (31.25%) and (12.6%) rudimentary horn shape. These findings are contrary to the results of Solomon. (2008), who reported that above 50% Arsi Bale female sheep were horned (52%).

Table1.Descriptions of qualitative traits of indigenous sheep in study area

Characters	Attributes	Sex					
		Female		Male		Overall Total	
		N	%	N	%	N	%
Body condition	Thin	99	22.20	22	17.20	121	19.70
	Average	342	76.68	84	65.60	426	71.14
	Fat	5	1.12	22	17.20	27	9.16
Coat color pattern	Plain	206	46.24	62	48.62	268	47.43
	Patchy	238	53.33	65	50.46	303	51.90
	Pied/spotted	2	0.43	1	0.92	3	0.68
Coat color type	Red	110	24.73	26	20.18	136	22.46
	White	22	4.95	14	11.01	36	7.98
	Brown	5	1.08	1	0.92	6	1
	Black	35	7.96	2	1.83	37	4.90
	Grey	6	1.29	2	1.83	8	1.56
	Light red	50	11.18	21	16.51	71	13.85
	Dark brown	27	6.02	13	10.09	40	8.06
	Red and brown with red dominant	81	18.06	27	21.10	108	19.58
	White and red with white dominant	72	16.13	12	9.17	84	12.65
	Black and white with black dominant	38	8.60	9	7.34	47	7.97
Hair type	Short and smooth	65	14.57	19	14.68	84	14.63
	Medium and smooth	371	83.19	103	80.73	474	81.96
	Long and smooth	10	2.24	6	4.59	16	3.41
Face profile	Flat	362	81.17	84	65.63	446	73.4
	Concave	50	11.21	19	14.84	69	13.03
	Convex	34	7.62	25	19.53	59	13.57
Wattle	Present	43	9.64	2	1.56	45	5.6
	Absent	403	90.36	126	98.44	529	94.4
Ruff	Absent	446	100	128	100	574	100
Tail shape	Straight tip	431	96.64	121	94.53	552	95.58
	Twisted end(curved at tip)	15	3.36	7	5.47	22	4.42
Tail type	Long fat	445	99.78	128	100	573	99.89
	Short fat	1	0.22	-	-	1	0.11
Ear orientation	Erect	23	5.15	20	15.62	43	10.4
	Semi pendulous	95	21.30	49	38.28	144	29.8
	Carried horizontally	328	73.54	59	46.0	387	59.8
Horn	Present	112	25.11	112	87.5	224	56.30
	Absent	334	74.89	16	12.5	350	43.7
Horn shape	Straight	36	32.15	35	31.25	71	31.7
	Spiral	51	45.53	63	56.25	114	50.89
	Rudimentary	25	22.32	14	12.5	39	17.41

3.3. Body Weight and Linear body measurements

Body weight: Information on body weight and physical linear measurements of specific sheep population at constant age has paramount importance in the selection of genetically superior animals for production and reproduction purpose (Yoseph, 2007).In this study, body weight of indigenous sheep (both sex) showed an increment with an increase in age of the animals. Thus, body weight change of female sheep population was 8.97kg, 1.55kg and 2.67kg as the animal grows from 0PPI to 1PPI, from 1PPI to 2PPI and from 2PPI to 3PPI dentition class whereas the change for males at similar dentition classes was 8.39kg, 3.98kg and 4.12kg, respectively, The change in body weight was higher as the animal grows from 0PPI to 1PPI for both sexes. This might be due to the wide age range of the sample populations. From this study, it can be shown that the sample sheep populations attain their mature weight when they had ≥1PPI. Similar trend was reported for Bonga (Zewdu, 2008) and Horro sheep breeds (Sisay, 2009).

The body weight of indigenous sheep recorded in this study was less than 34.14 kg reported for Gumuz sheep (Solomon, 2007), 30.7 kg reported for the North western low land sheep (Sisay, 2009), and 29.0 kg reported for Bonga and Benchmaj sheep (Dejen, 2010). On the other hand, the value was higher than those noted for Central highland (24.6kg) and Rift valley sheep (24.7kg).

Sex effects: In this study, sex of animals had significant ($p<0.05$) effect on body weight and most of linear body

measurements (LBMs) except EL, PW and TL (Table 2). Differences in live weight and most of the LBMs between sexes observed in this study showed that these parameters are sex dependent. Male sheep were consistently heavier than females across all the significantly affected variables except some that were not significant ($p<0.05$). Ewes have slower rate of growth and reach maturity at smaller size compared to males due to the effect of estrogen which restricts the growth of the long bones of the body (Sowande and Sobola, 2007).

Age effects: The variation between the different age classes were found to be significant ($p<0.05$) as detected by pair-wise comparisons for both sexes (Table 2). The trend showed that all linear body measurements increased with increase in dentition class. The present study was similar with Yoseph (2007) who reported that the size and shape of the animal increases until the animal reaches its optimum growth point or maturity. Similar finding was reported by Fasae et al. (2006) who noted that body weight and body measurements increased with age of ewes for the first three years.

Sex by age group: The interaction of sex and age group were only significant ($p<0.05$) for PW and EL. Body length of males in the youngest, intermediate and oldest age group of sampled sheep population were 56.4, 62.1, 62.3 and 62.5, respectively and the corresponding value for females were 54.7, 60.2,60.7 and 61.5, respectively. In the youngest, intermediate and oldest age groups, body lengths of males were higher than females (Table 2). Body weights (BW), chest Girth (CG), Wither Height (WH) of sampled female population at youngest age group were 16.5 Kg, 57.3 cm and 51.22 cm, respectively, while it was 20.96 Kg, 62.12 cm and 55 cm, respectively, for males. Similarly, Mengstie *et al*. (2010) reported that male sheep are larger than female sheep with quantitative traits in north western highlands of the Amhara region.

Table2. Least squares means and standard error (LSM ± S.E) of body weight and LBMs (cm) for sampled sheep population in study area.

Effect	N	EL	BW	BL	CD	CG	HW	PW	TL	TC	SC
		LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Overall Mean	574	10.3± 0.07	27.6±0.5	60.2±0.3	23.2±0.08	68.5±0.6	60.2±0.5	17.2±0.54	32.73±0.54	20.17±0.3	24.9±1.06
CV		7.6	21	5.95	3.97	9.57	9	10	17.81	16	0.16
R^2		0.24	0.49	0.38	0.38	0.43	0.39	0.37	0.45	0.05	27.56
Sex		Ns	*	*	*	*	*	ns	*	*	
Female	446	10.34±.03	24.9±.25^{b}	59.3±.17^{b}	22.81±.04^{b}	66.87± .3^{b}	58.5±.25^{b}	17.11± .08	31.96±.27^{b}	19.41± .75^{b}	-
Male	128	10.3±0.14	30.2±.9^{a}	61.1±.6^{a}	23.56±.17^{a}	70.1±1.2^{a}	61.9±.99^{a}	17.35±.32	33.5±1^{a}	20.93±0.6^{a}	24.9±1.06
Age		Ns	*	*	*	*	*	*	*	*	*
0PPI	220	9.7±.05	18.7±.35^{d}	55.6±.23^{c}	21.9± .06^{d}	59.7±.42^{d}	53.1±.35^{d}	15.3 ±.11^{d}	26.3±.38^{d}	19.4±0.21^{cd}	19.7±.53^{d}
1PPI	83	10±.15	27.6±.1^{c}	61.5±.7^{ab}	23.26±.17^{bc}	69.7±1.25^{c}	61.4±1^{c}	16.86±.33^{c}	30.7±1.1^{c}	19.6±0.62^{bc}	22.6±2.13^{c}
2PPI	125	10.64±.16	30.3±1^{b}	61.8±.73^{b}	23.46±.18^{b}	71.4±1.3^{b}	62.9±1.1^{b}	18±.35^{ab}	34.5±1.18^{b}	19.67±0.6^{ab}	26.5±2.3^{b}
3PPI	146	10.8±.2	33.8±1.3^{a}	62.1±.88^{a}	24.11±.23^{a}	73.16±1.6^{a}	63.5±1.33^{a}	18.7±.43^{a}	39.3±1.4^{a}	22±0.8^{a}	31.00±2.8^{a}
Sex by age		*	Ns	Ns	Ns	ns	Ns	*	Ns	ns	-
F0	109	9.7±.0.07	16.5±0.5	54.7±.33	21.6±.08	57.3±.0.6	51.2±0.5	14.9±.85	25.2±0.5	18.8±0.3	-
F1	76	10.4±.0.08	25.8±0.6	60.2±.4	23±.0.1	68.34±.73	59.95±.6	17.6±.19	30.1±0.6	19.1±0.36	-
F2	119	10.5±0.07	27.3±.47	60.7±.32	23.11±.08	70±.58	60.67±.48	17.63±.15	33.3±.5	19.8±.28	-
F3	142	10.7±.06	30±.43	61.5±.3	23.47±.07	71.8±0.53	62.3±.44	18.27±.14	38.7±0.47	19.9±.26	-
M0	111	9.6±.0.07	20.9±.5	56.4±.33	22.2±.08	62.12±.0.6	55±.5	15.6±.0.16	27.4±0.5	19.5±0.3	19.7±.53
M1	7	9.7±.0.3	29.4±2	62.1±1.3	23.4±.34	71.1±2.4	62.2±1.99	16.1±0.64	31.4±.5	20±1.2	22.6±2.13
M2	6	10.86±0.3	33.3±2.1	62.3±1.4	23.92±.36	72.75±2.6	64.75±2.15	18.5±.0.7	35.3±2.3	20.1±1.28	26.5±2.3
M3	4	10.8±0.38	37.5±2.6	62.5±1.7	24.7±.45	74.5±3.17	65.8±2.6	19.12±.0.8	39.7±2.8	24.14±1.57	31.±2.82

*Means with different superscripts within the same column and class are statistically different (at $p<0.05$). Ns = non significant; * Significant at 0.05; 0 PPI = 0 pair of permanent incisors; 1PPI = 1 pair of permanent incisor, 2 PPI = 2 pair of permanent incisor, and 3pairs of permanent incisors.*

3.4. Correlation between body weight and other linear body measurements

The association among body weight and linear body measurements of sheep in the study area is presented in Table 3. The high association of LBMs with body weight would imply that these measurements can be used as indirect selection criteria to improve live weight (Kosgey*et al.,* 2006; Solomon, 2008) or could be used to predict body weight (Attach and Elkhidir,2004; Afolayan*et al.,* 2006; Fasae*et al.,* 2006). Almost all of the parameters considered had positive and significant correlation with live body weight. Among measured linear quantitative variables chest girth (r=0.78 for female and r=0.91 for male) had the highest positive association. It explains about 78% and 91% of the variation in body weight in females and males, respectively.

The better association between body weight and chest girth was possibly due to relatively large contribution in body weight by chest girth which consists of bones, muscles and viscera (Thiruvenkadan, 2005).This suggests that either this variable alone or by combining with other linear quantitative variables (which will be determined later using multiple linear regression analysis in the next chapter) could provide a good estimate for predicting live body weight of sampled population of study area. Similar to this study, the strong positive correlation between the dependent variable body weight and the independent variable chest girth to predict the body weight were observed in different sheep breeds for instance Gumez (Solomon,2007), Menz and Afar (Tesfaye,2008) and Bonga and Horro(Zewdu,2008) sheep breed of Ethiopia. Variables such as body length, height at wither and pelvic widths, which are directly related to the size and weight of the animal, displayed medium to high positive correlations with one another both in female and males animals.

Table3.Coefficient of correlations between body weight and linear body measurements of sampled population (above the diagonal for males and below the diagonal for females; Female= 446& Male = 128)

Trait	EL	BW	BL	CD	CG	HW	PW	TL	TC	SC
EL		0.56**	0.54**	0.40**	0.57**	0.47**	0.49**	0.407**	0.25**	0.11ns
BW	0.48**		0.88**	0.77**	0.915**	0.83**	0.82**	0.74**	0.63**	0.25**
BL	.11**	0.17**		0.74**	0.914**	0.808**	0.78**	0.72**	0.69**	0.18*
CD	0.44**	0.69**	0.11*		0.77**	0.73**	0.64**	0.67**	0.56**	0.23*
CG	0.47**	0.78**	0.17**	.72**		0.86**	0.83**	0.74**	0.68**	0.18*
HW	0.47**	0.78**	0.16**	.66**	0.83**		0.76**	0.63**	0.630**	0.12
PW	0.47**	0.73**	0.16**	.67**	0.73**	0.73**		0.706**	0.62**	0.25**
TL	0.30**	0.41**	-0.13**	0.37**	0.37**	0.38**	0.34**		0.62**	0.28**
TC	0.13**	0.19**	0.09	0.06	0.12*	0.12*	0.23**	0.04ns		0.16ns

**Correlation is significant at the 0.05 level (2-tailed).ns: non significant*
***Correlation is significant at the 0.01 level (2-tailed*

3.5. Prediction of Body Weight from Linear Body Measurements

Regression analysis is commonly used in animal research to describe quantitative relationships between a response variable and one or more explanatory variables such as body weight and body measurements (chest girth, chest depth, body length and height at wither) especially when there is no access to weighing equipment (Cankaya, 2008). Multiple linear regression models for predicting the body weight of sheep from linear body measurements are presented in Tables 4 and 5.

In this study, all the body measurements of indigenous sheep were fitted into the regression model and through elimination procedures, the optimum model was identified. Chest girth, height at wither, pelvic width, chest depth, tail length and tail circumference were the best fitted model for female sheep, whereas chest girth, body length, pelvic width and chest depth were the best fitted model for male sheep. However, predictions of body weight from combinations of LBMs, having these multiple variables possess a practical problem under field settings due to the higher labor and time needed for measurement. Moreover, the change in R-square due to inclusion of additional variables in the model was not strong strengthening the preceding argument that chest girth alone could serve as a best predictor of body weight under field condition. Measuring heart girth with tape is easy, cheap and rapid. Thus, body weight prediction from chest girth alone would be a practical option under field conditions with reasonable accuracy.

Thus, body weight of indigenous sheep population of Bensa district could be estimated using the following linear regression equation.

$y = -20 + 0.67x$ for female and

$y = -29 + 0.8x$ for male sheep; where y and x are body weight and chest girth, respectively.

Table 4. Multiple linear regression analysis of live body weight on different LBMs for female sheep

Equations	Intercept	β_1	β_2	β_3	B_4	B_5	B_6	R^2	A-R^2	SE
CG	-20±1.7	.67±0.02						0.60	0.6	4.2
CG+HW	-27±1.7	0.37±0.04	0.47±0.05					0.67	0.67	3.9
G+HW+PW	-29.96±1.7	.27±0.04	0.35±0.05	0.9±1.4				0.69	0.69	3.77
CG+HW+PW+CD	-45.6±4.1	0.2±0.04	0.34±0.05	0.75±1.4	1±.2			0.70	0.70	3.70
CG+HW+PW+CD+TL	-44±4.1	0.21±0.04	0.32±0.05	0.73±1.4	.93±.2	.06±.02		0.71	0.71	3.67
CG+HW+PW+CD+TL+TC	-47.6±4.2	0.21±0.04	0.32±0.05	0.64±1.4	1±.24	0.06±0.02	1.7±0.06	0.72	0.71	3.64

CH = chest girth; HW = height at wither; PW = pelvic width ; CD= chest depth, TL = tail length; R^2 = R-square; A-R^2 = adjusted R-square ;SE=standard error.

Table 5.Multiple linear regression analysis of live body weight on different LBMs for male sheep

Equations	Intercept	β_1	β_2	β_3	B_4	R^2	A- R^2	SE
CG	-29±2	.8±0.03				0.83	.83	3.34
CG+BL	-37.4±3	0.57±0.07	0.4±0.12			0.85	.85	3.2
CG+BL+PW	-37.8±2.9	0.46±0.08	0.37±0.11	0.58±0.2		0.86	0.85	3.1
CG+BL+PW +CD	-50.77±5.74	0.38±0.08	0.33±0.113	0.6±0.20	.88±.33	0.87	0.86	3

CH = chest girth;BL = body length; PW = pelvic width ; CD= chest depth; R^2 = R- square; A-R^2 = adjusted R-square ;SE=standard error

4. CONCLUSIONS

Indigenous sheep is long fat tailed type with the major coat color pattern varies from patchy, plain or spotted with smooth red, white and red with white dominant, black and white with black dominant. The head profile of

indigenous sheep is flat, without wattles. The majority of males are horned while most of females are polled.

The present study revealed that body weight and linear body measurements influenced by sex and age. Almost all of the parameters considered had positive and significant correlation with live body weight. The positive and significant relationship between body weight and linear body measurements indicated that fairly good knowledge of live weight of indigenous sheep could be estimated from chest girth measurements. In the regression analysis, Chest girth was the variable which explained more variation than other variables for both males and females to predict body weight of indigenous sheep populations. Male sheep had higher body weight and linear body measurements than female sheep. The morphological characterization of sheep type can only dimly reveal the genetic relationships between individuals, but it is a first step in classifying a population into a relatively homogenous. Therefore to increase the validity of this on farm phenotypic characterization study, it is important to undertake well planned genetic characterization of sheep type and then to improve their genetic potential in the study area.

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